Fume Hoods

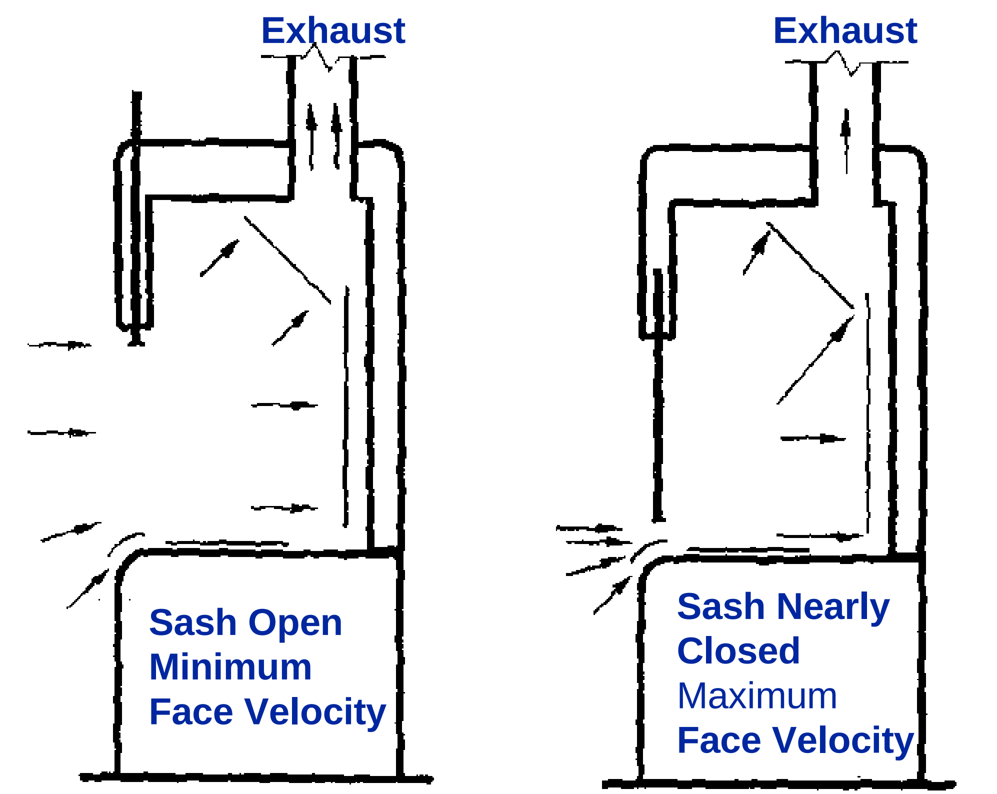
- Enclosed ventilated exhausted chamber
- Negative Pressure to contain and exhaust fumes
- Usually Sliding Sash for access
- "Face Velocity"
  - Volume and Speed of negative pressure airflow
  - Typically 100 Feet per Minute (FPM) + - 20%
  - This can equal 300 CFM in a 4 foot hood
- In a facility with a high density of hoods the hood demand can be the major building system design load

There are 4 basic types of fume hoods

- Conventional hoods
- By-pass hoods
- Auxiliary air hoods
- Variable volume hoods

Conventional Fume Hoods

- Oldest, Cheapest and Simplest type of Fume Hood
- Basically an enclosed chamber with exhaust and sliding sash
- Face velocity is simply a function of the sash opening
- No way to provide uniform face velocity
- Creates low velocity at open sash position and high velocity when sash is nearly closed
- Can result in ineffective capture



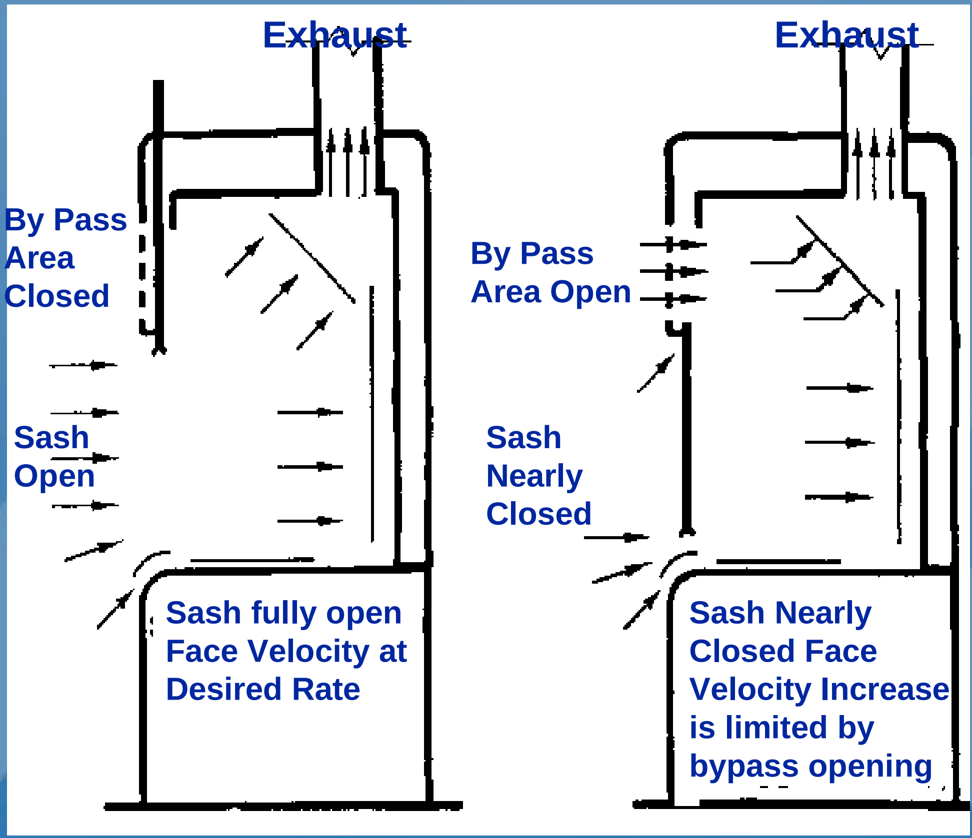
Conventional Fume Hood Airflow Characteristics

From "Laboratory Control and Safety Solutions Application Guide" Landis & Gyr Inc. Rev 2- Sept 1994

Siemens Building Technologies, Inc.
Landis Division

By-Pass (Constant Volume) Fume Hoods

- Air By Pass opening grille provided above sash
- Opens and closes with sash to provide equivalent sash opening area
- Maintains uniform face velocity regardless of sash position
- Simple but highest energy demand since constant volume is continuously exhausted
- Room must be rebalanced if hoods change



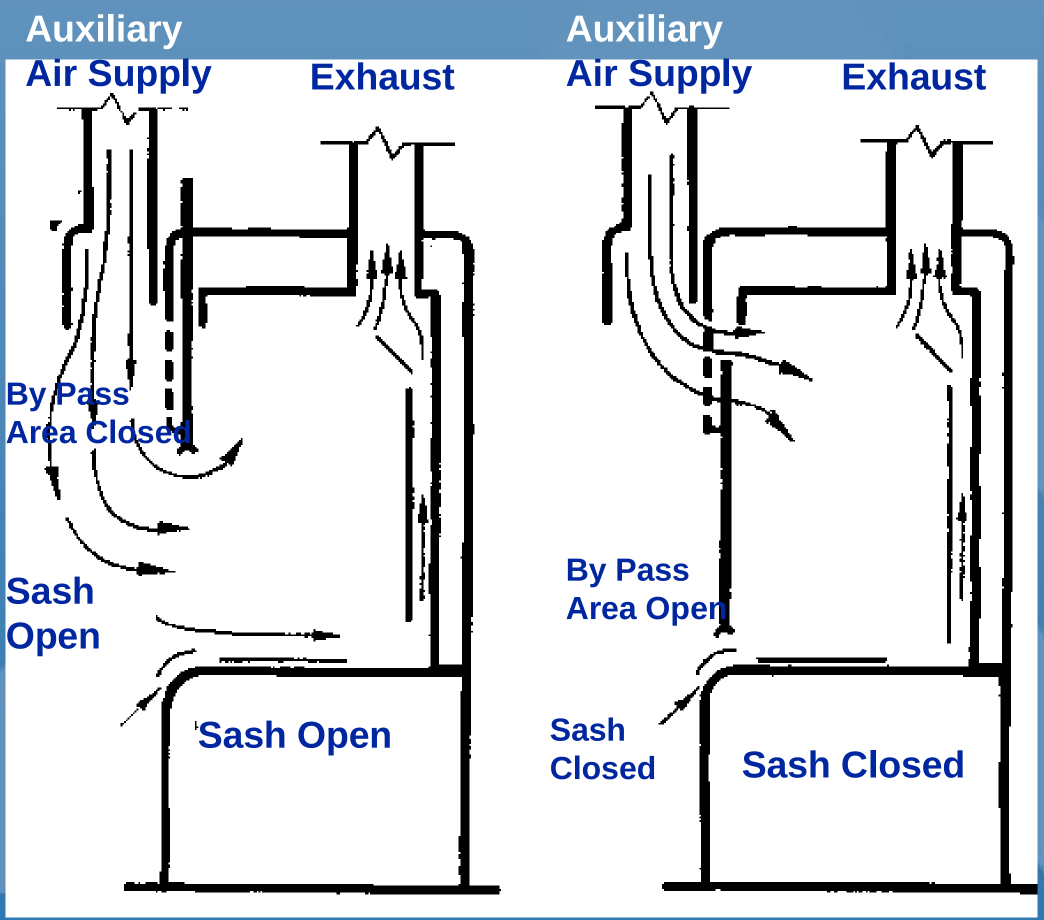
By Pass Fume Hood Airflow Characteristics

From "Laboratory Control and Safety Solutions Application Guide" Landis & Gyr Inc. Rev 2- Sept 1994

Siemens Building Technologies, Inc.
Landis Division

Auxiliary Air Fume Hoods

- Provides an auxiliary air supply to substitute for up to 70% of room air exhausted
- Known as “make -up air hood”
- Several Disadvantages
- installation of auxiliary system can be costly & difficult
- does not draw vapors out of room
- introduces outside air temperature and humidity into hood



Auxiliary Air Fume Hood Airflow Characteristics

From “Laboratory Control and Safety Solutions Application Guide” Landis & Gyr Inc. Rev 2- Sept 1994

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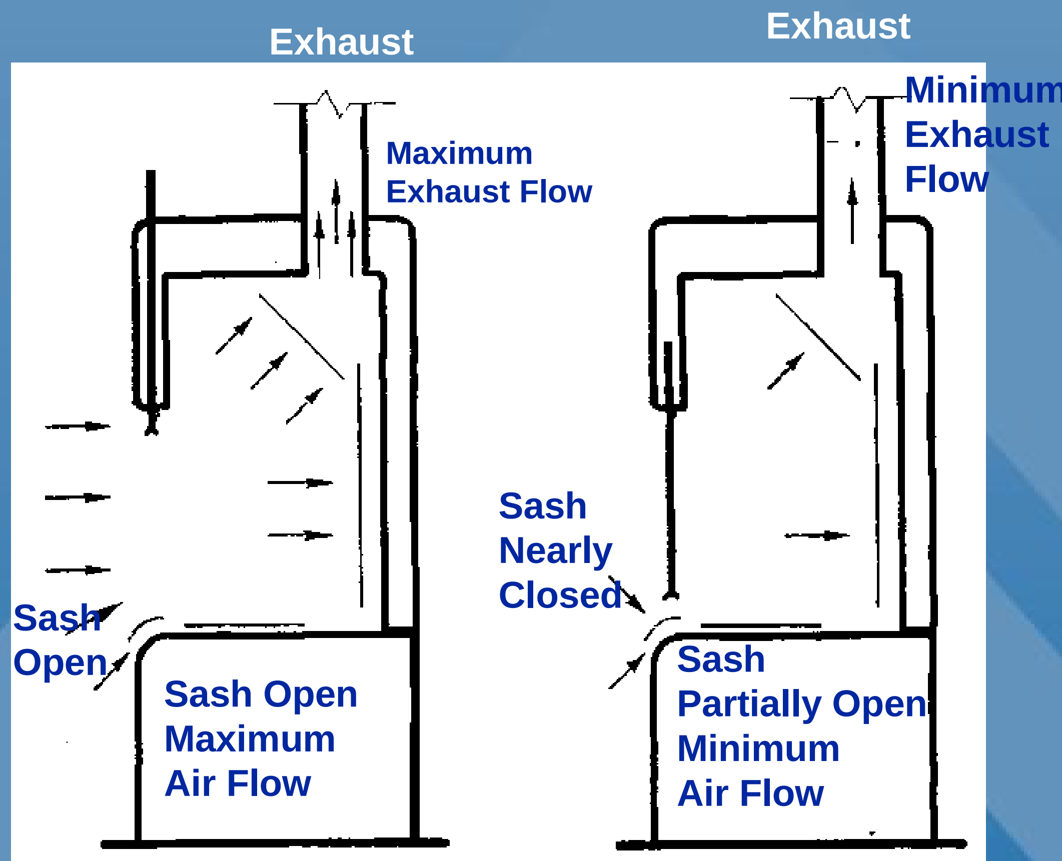
Variable Air Volume (VAV) hoods

NIH BUILDING 50

- Varies Exhaust Volume to maintain Face Velocity as Sash is opened or closed
- Only exhausts as much air as necessary to meet need
- Requires Sash monitoring system and fume hood controller tied into room supply and exhaust system
- VAV Hoods can be changed without rebalancing room
- Very complicated, much more difficult to design, install and commission
- More expensive initially but saves significant energy



Variable Air Volume Fume Hood Airflow Characteristics

From "Laboratory Control and Safety Solutions Application Guide" Landis & Gyr Inc. Rev 2- Sept 1994

Siemens Building Technologies, Inc.
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Fume Hood Comparisons

Conventional Hoods and Auxiliary Air Hoods are not frequently used

Comparison is usually between CV and VAV Fume Hoods and is similar to overall CV and VAV Central Supply & Exhaust Systems comparisons

- Initial cost vs. life cycle cost
    - VAV more expensive but can save 30% to 70% of CV energy costs
- Maintenance staff capabilities
    - VAV requires more highly trained maintenance
- Need for flexibility
    - VAV is more flexible and responsive to change

To realize VAV systems savings the users must be trained and cooperate in keeping the sashes closed except when the hoods are being loaded.

Building 50 Selected VAV Fume Hoods

NIH BUILDING 50

- The NIH Design Guidelines allowed us to use a VAV Supply and Exhaust system and VAV hoods are most effective with this.
- VAV Hoods reduce the amount of air for hood exhaust and thus reduce the required airflow and energy costs of the air handling systems
- The initial costs are higher but the life cycle costs quickly payback the initial investment
- VAV Hoods are independent and changes can be made without having to rebalance the entire system, which is an advantage at NIH where change is constant.
- Building 50 is the first facility at NIH to install VAV Hoods, all previous fume hoods campus wide are Constant Volume By Pass hoods
- This will make it necessary to stress to the occupants that hoods must be closed except when they are being loaded, for maximum energy efficiency

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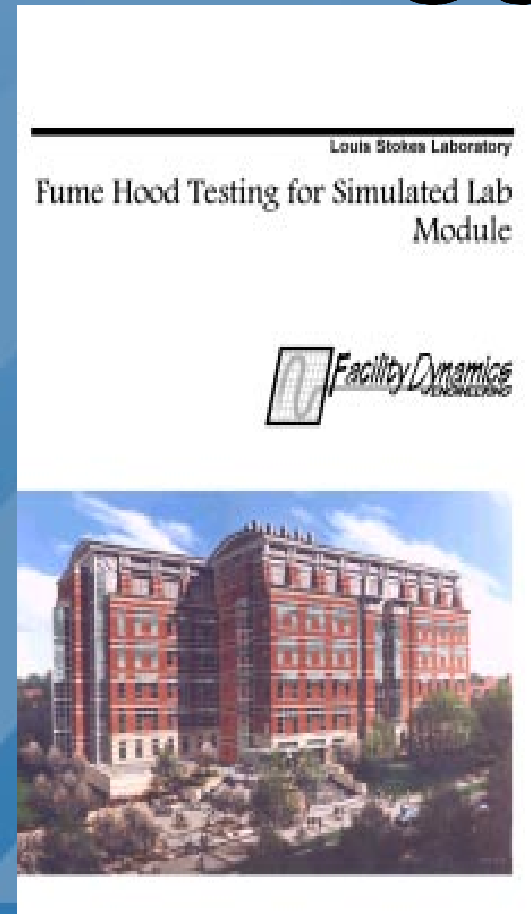
Fume Hood Mock Up and Testing

- **Goal of testing was to Prequalify the VAV Lab Fume Hood and Fume Hood Control System**
  - Verify hoods can meet specified containment criteria
  - Verify control system can meet specified performance criteria
  - Assess quality of overall Lab / Fume Hood configuration
- **BELL Created a Simulated Lab Module with all actual Building 50 components**
- **The testing involved the following entities**

The BELL Company, General Contractor
ISEC, the hood supplier;
SIEMENS, the Controls Contractor;
RMF, the Mechanical Engineering Consultant;
CRSS, the Government's Construction Manager
FACILITIES DYNAMICS, the Commissioning Agent;
WEISMAN INC, the Testing and Balancing Contractor;
ADELAIDE ASSOCIATES, conducted ASHRAE110 tests
NIH / ORS Div of Safety and Div of Engineering


Louis Stokes Laboratory

Fume Hood Testing for Simulated Lab Module

Fume Hood Testing Report

WEISMAN INC.

Fume Hood Mock Up Configuration

- The BELL Company created a mock up in an EPA lab they were constructing

2 Hoods on the VAV exhaust up stream

Fume Hood Alcove with test hood

- 2 hoods were installed upstream to simulate adjacent lab fume hood use
- A plywood mock up wall created the Building 50 Alcove configuration with
  - VAV fume hoods
  - Supply and Exhaust VAV Terminal Boxes
  - 1 Exhaust Inlet and 1 Supply Outlet
  - Tracking System - Lab Room Controller, fume hood controller and hood exhaust control valve

Fume Hood Testing

Face Velocity and Dynamic Response Testing

Measuring Face Velocities at differing sash openings

Computerized recording and graphing of the dynamic events

- **Face Velocity Test** - a grid of face velocity measurements was taken across the face of the hood with the sash in various positions

- **Dynamic Response Tests** - response testing measures the hood performance in various "dynamic events" such as sash movements, walk bys and opening and closing the lab door or opening and closing upstream fume hoods; for:
  - steady state face
  - velocity
  - maximum deviation
  - time to steady state
  - overshoot

Fume Hood Testing
Tracer Gas Containment Tests

NIH BUILDING 50

Containment test using Manikin with detector probe

ASHRAE 110 with NIH modifications to more truly simulate loaded fume hood condition

- **Tracer Gas Containment** - this addresses the containment of the hood with a sulfur hexafluoride gas release and a detector on the face of a manikin.

- **The ASHRAE 110 -Method of Testing Performance of Laboratory Fume Hoods 110** was modified by NIH with the addition several elements to simulate actual apparatus in the Hood.

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Fume Hood Testing

Flow Visualization Testing

Large volume smoke bomb set off in hood

Sash is raised and lowered; smoke is contained in hood

Large Volume visualization - a smoke bomb was set off to look for leakage in static & dynamic (sash movement and walk by) conditions.

Local Visualization - using a titanium tetrachloride smoke gun to check for small leaks around the edges of the hood

All large volume and local visualization tests indicated that the capture was adequate under all conditions including rapid sash movement.

ORS

Energy Recovery Systems

NIH BUILDING 50

The most important and largest application of energy recovery in research Facilities is the heat recovery of the once thru air in the laboratory exhaust systems

This can be accomplished with:

- **Plate Type**- thin metallic sheets in air streams
- **Heat Pipe** - horizontal tubes with liquid refrigerant in air streams
  - positive separation, no moving parts, moderate cost, low maintenance
  - air streams must be side by side,
  - systems are 50 % to 70% effective
  - sensible heat transfer only; no latent (moisture) energy recovery
- **Run Around Coils** - 2 air to liquid heat exchangers in air streams
  - positive separation, moderate cost,
  - 45% to 65% effective,
  - sensible heat transfer only ; no latent (moisture) energy recovery
  - can be remote, air streams do not have to be side by side
  - liquids have to be pumped, requiring energy and more maintenance
- **Heat Wheels** - heat absorbing desiccant disk rotates sequentially through and transfers energy from the exhaust and supply airstreams
  - recovers sensible and latent energy, higher efficiency of 70%to 80%
  - air streams must be side by side, potential for contamination between them
  - higher initial cost, moving parts requiring more energy and maintenance

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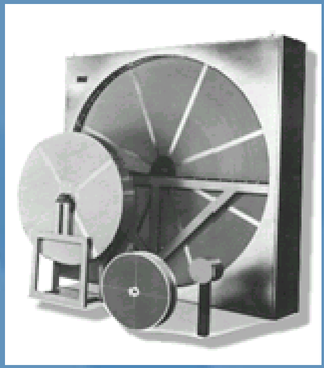
NIH BUILDING 50

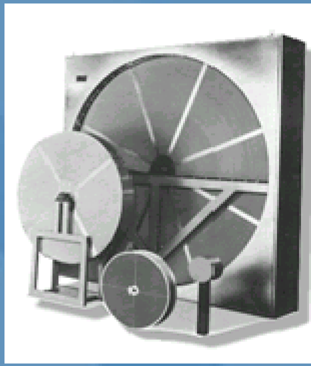
Building 50 Selected a Desiccant Energy Recovery Wheel Concept



- A complete Life Cycle Cost study was conducted on all of the various types of energy recovery systems.
- The desiccant energy recovery wheel concept was by far the most cost effective system.
- A major factor is that this is the only system that recovers latent as well as sensible energy, which is very important in the high humidity summer conditions in Bethesda.
- Based on prior successful applications on similar laboratory facilities at nearby Johns Hopkins and Georgetown Universities, RMF, the mechanical engineering consultant highly recommended this desiccant energy recovery wheel concept.
- NIH researched these two projects and found them to be highly successful The Office of Research Services, Division of Safety and Division of Engineering, Maintenance Engineering Section personnel visited both sites and carefully considered all of the advantages and disadvantages of the energy recovery wheel concept.

ORS Office of Research Services

NIH accepted the Energy Recovery Wheel Concept with the following limitations:

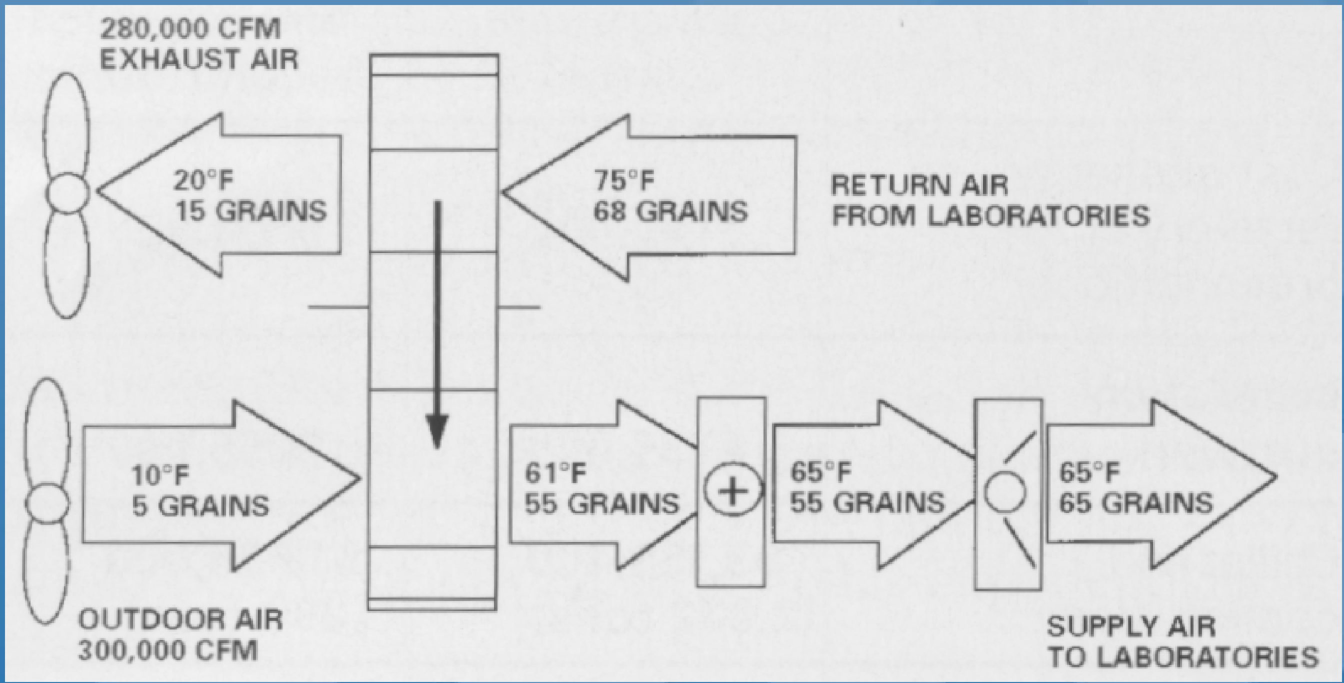


- The Office of Research Services carefully considered the desiccant energy recovery wheel concept in the design of Building 50 and accepted it with the following conditions/ restrictions:
  - Division of Safety
    - No containment devices exhausted through the wheels
    - They do not want to risk re-entrainment of contaminants
    - This requires a separate fume hood exhaust system and results in less volume of air to the wheels, and thus less energy savings
  - Division of Engineering / Maintenance Engineering Branch
    - Design / Size base building system without heat wheel factors
    - They are concerned about insufficient building capacity if for any reason the energy wheels had to be abandoned in the future
    - This results in us not realizing the maximum benefit of downsizing the building base system design to take full advantage of the energy recovery of the wheels

Energy Recovery Wheel Concept

Heating Mode

Outgoing Warmer Air Exhaust Flow raises the temperature of the energy wheel which in turn then spins through and raises the temperature of the cooler incoming outdoor air

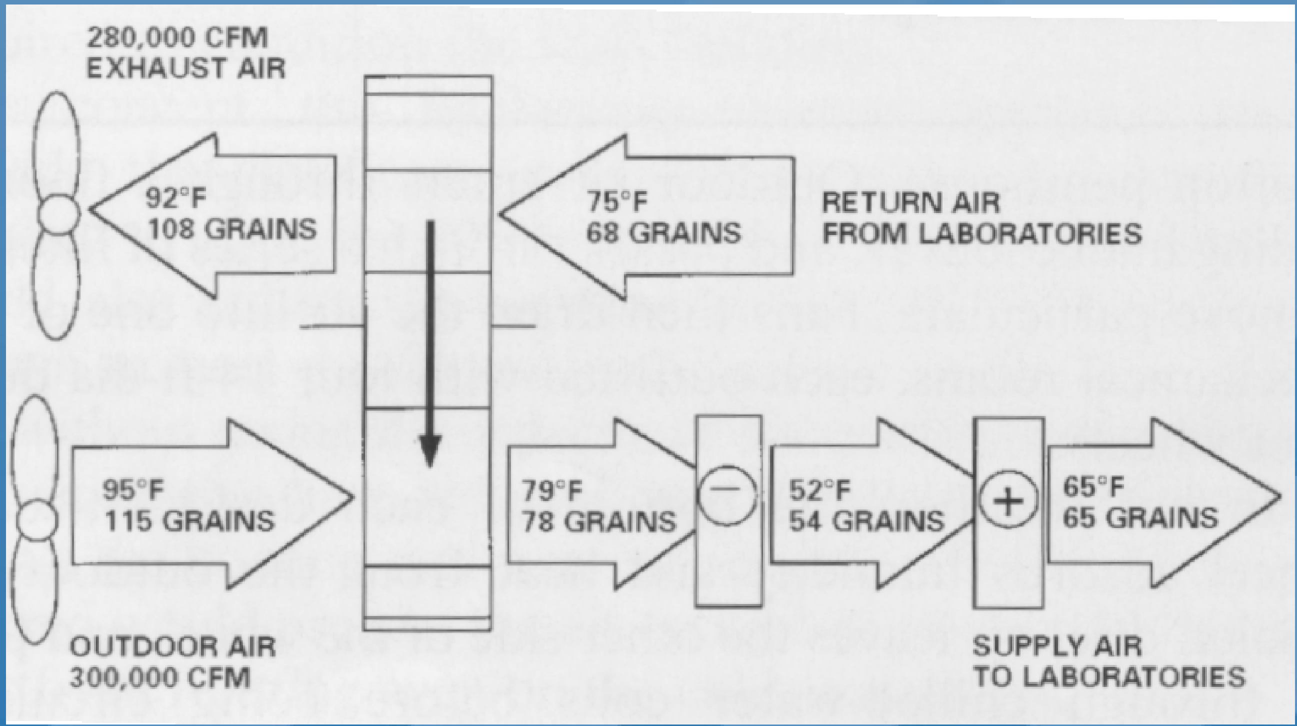


Schematic of Energy Recovery Wheel in Heating Mode

Energy Recovery Wheel Concept

Cooling Mode

Outgoing Cool Air Exhaust Flow lowers the temperature of the Energy Recovery wheel which in turn then spins through and lowers the temperature of the incoming outdoor air



Schematic of Energy Recovery Wheel in Cooling Mode

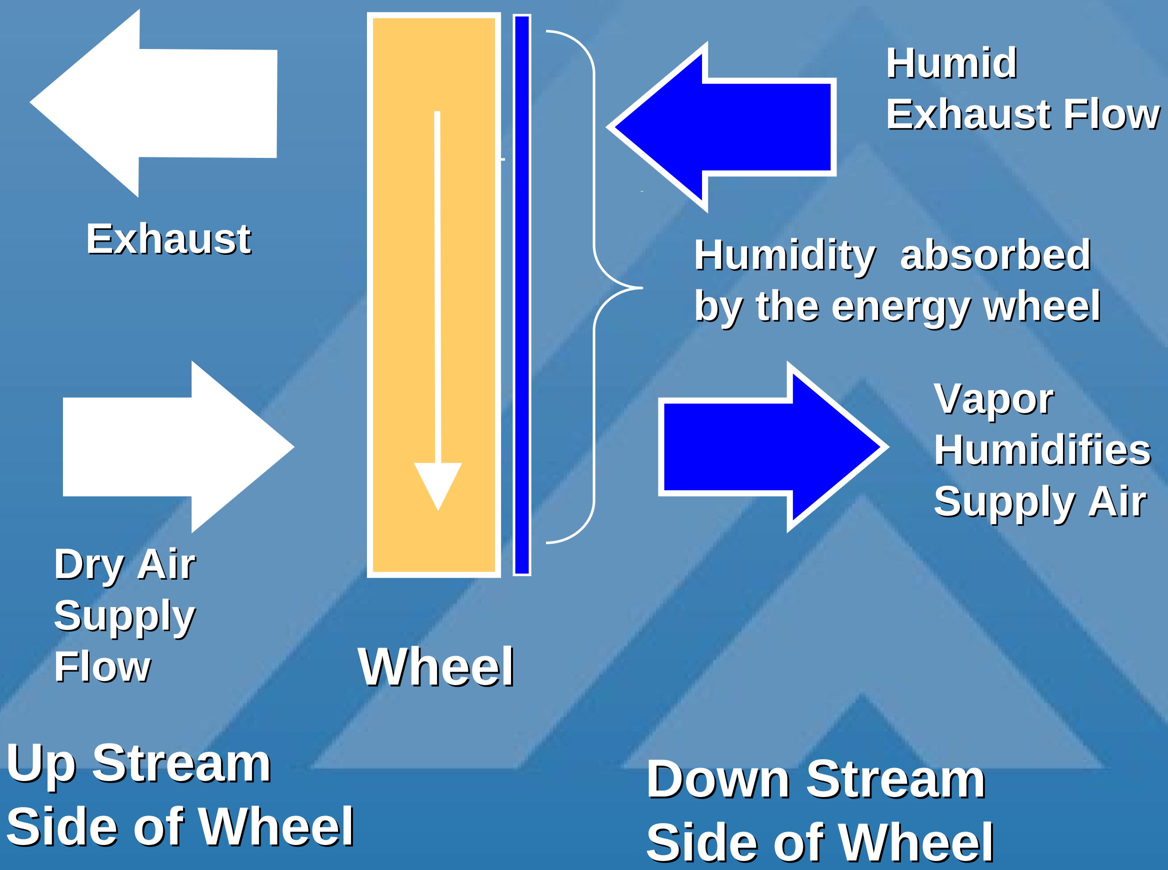
Energy Recovery Wheel Concept

Humidity Retention in Heating Mode

NIH BUILDING 50

In the heating season the water vapor in the humid exhaust air is absorbed by the energy wheel and retained.

It is then captured by and humidifies the incoming drier supply air.



Schematic of Humidity Retention in Heating Mode

Drawing by Frank Kutlak

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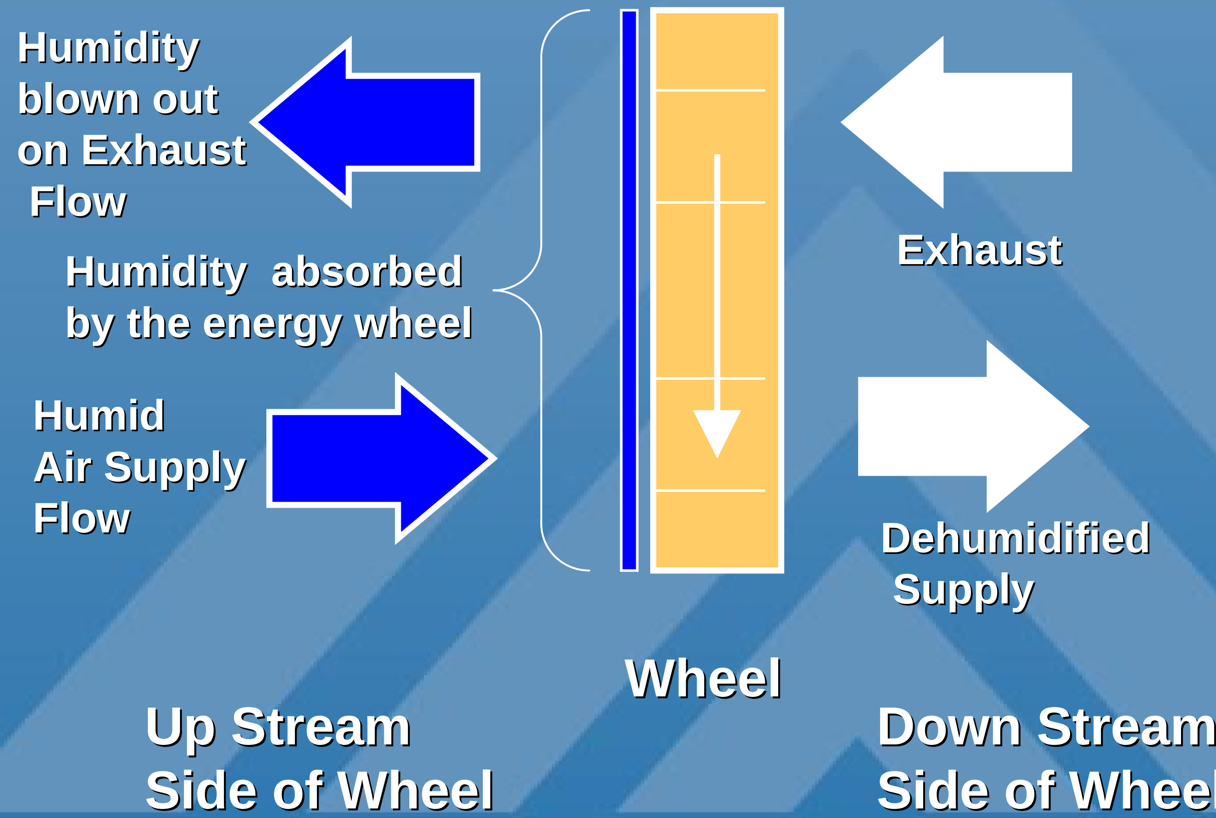
Energy Recovery Wheel Concept

Humidity Rejection in Cooling Mode

NIH BUILDING 50

In the cooling season the water vapor in the humid supply air is absorbed by the energy wheel and filtered out of the supply.

It is then rejected by the exhaust flow.



Schematic of Humidity Rejection in Cooling Mode

Drawing by Frank Kutlak

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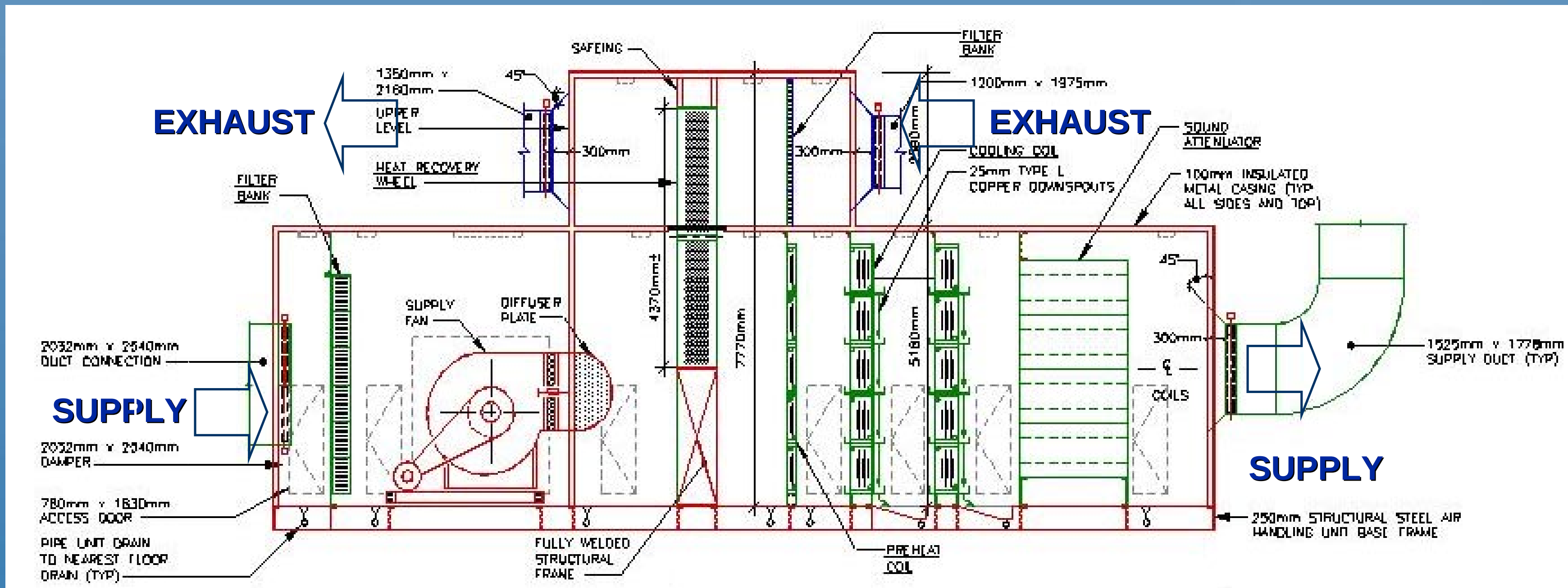
Air Handler Design

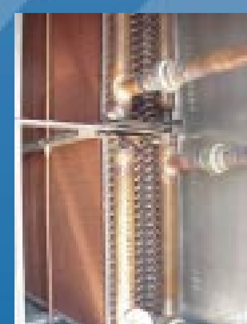


Section of 50,000 CFM AHU with Energy Recovery Wheel


Filter Bank


Fan Motor and Fan


Heat Wheel


Cooling Coil


Sound Attenuator


AHU being installed

NIH BUILDING 50

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Energy Recovery Wheel

- Section of the Building 50 Custom Air Handler with SEMCO Energy Recovery Wheel frame installed in the fabrication yard of Energy Labs Inc. in Tijuana Mexico
- Each of the 8 AHU's will be equipped with a wheel and will be shipped in 5 bottom and 1 top sections.
- The actual Energy Recovery Wheel will be installed in the field

Energy Labs Inc

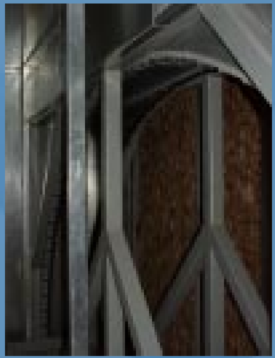
SEMCO INCORPORATED

NIH Building 50
Energy Conservation Features

Mechanical Systems

There are five major mechanical elements that contribute to the increased energy efficiency of Building 50.

- Energy Recovery Wheels
- Variable Air Volume (VAV) Supply and Exhaust Systems
- Variable Frequency Drive (VFD) fans
- Variable Frequency Drive (VFD) pumps
- Variable Air Volume (VAV) fume hoods



Heat Wheel

VAV Exhaust Fans

VAV Terminal Boxes

Office of Research Services

ORS

Air Handler Testing

- *The Bldg 50 Management team visited the Energy Labs factory to participate in the testing of the Custom Air Handlers*

- The Tests included
  - Overall Conformance to Contract Documents and Quality Inspection
  - Fan Volume Testing
  - Leak Testing of Unit
  - Face Velocity Across Coils

Building 50 AHU sections in factory production line

Energy Labs Inc

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NIH BUILDING 50

Air Handler Testing

Energy Labs has a testing chamber they use to verify the AHU fan output

Building 50 AHU in background connected to test chamber in foreground

Interior of test chamber with funnels to measure fan output

Reviewing Instrument readouts in testing office.

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Energy Labs Inc

Air Handler Testing

Two RMF Mechanical Engineers take readings to verify uniform velocity across face of the coils

Leak Testing. Entire Unit is pressurized to check for leaks.

AHU's were tested for leaks and uniform velocity across the face of the coils

Overall the units passed all of the tests and had minimal quality issues which were corrected

Energy Labs Inc

Air Handler Installation

• The units had to be transported from California on 30 escorted tractor trailers to a holding yard in Baltimore

• The 8 main roof top air handlers were comprised of 28 sections weighing from 12,000 to 38,000 lbs. each

• BELL had to lease a 200 ton crane with a special jib boom to lift them to the mechanical penthouse

Air Handler Installation

Setting last section of AHU #2 in West wing

The AHU sections were carefully set on steel framing over an acoustical slab in the west and east wings.